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Certification

Canadian Patent Office
Certification

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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,449,538**, on November 14, 2003, by **DYNAMIC FUEL SYSTEMS INC.**, assignee of Thomas Fairfull, Mohamed Ali Mohamed Ahmed Soliman and Armen Kohler, for "Oxygen/Hydrogen Generator for Internal Combustion Engines".

PRIORITY DOCUMENT
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December 17, 2004
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Canada

(CIPO 68)
31-03-04

OPIC CIPO

ABSTRACT

There is provided a new and useful electrolytic oxygen/hydrogen generator for use with internal combustion engines and in other areas. Also provided are components for use in the generators.

TITLE OF THE INVENTION

OXYGEN/HYDROGEN GENERATOR FOR INTERNAL COMBUSTION ENGINES

FIELD OF THE INVENTION

This invention relates to electrolytic oxygen/hydrogen generators and to an anode arrangement for use in such generators.

BACKGROUND OF THE INVENTION

It has been proposed to introduce a proportion of hydrogen and/or oxygen into a fuel mixture for burning in an internal combustion engine, in order to increase the efficiency of burning. The intended result is reduced noxious emissions to the environment, reduced engine maintenance and reduced fuel costs.

To date many devices have been proposed for this purpose, but none has come into widespread use.

PRIOR ART

Applicant is aware of the following patents and published applications which pertain to this subject matter:

U.S. Patent No. 4,442,801, to Glynn, et al.;
U.S. Patent No. 4,392,937, to Schmitt, et al.;
U.S. Patent No. 4,028,208, to Giacopeli;
U.S. Patent No. 4,369,737, to Sanders, et al.; and
Canadian Patent No. 1,113,037, to Boulton.

BRIEF SUMMARY OF THE INVENTION

The invention provides an oxygen/hydrogen generator which includes improved components in a novel structural combination.

In one embodiment the invention provides an anode arrangement for use in a hydrolysis cell for generating hydrogen and oxygen gases, the arrangement comprising a stack of perforated electrically conducting wafers, vertically spaced from each other, and a connector for connecting each wafer to an electrical circuit.

In a further embodiment there is provided a hydrolysis cell for generating hydrogen and oxygen and which comprises a casing which is at least in part electrically conducting and comprises a cathode, and has within it an anode arrangement as described above. The cell includes means for the introduction of make-up liquid and for removing produced gas.

In a further embodiment there is provided a hydrogen and oxygen generator comprising an electrolytic cell having a casing, an anode, a cathode, an inlet and first and second outlets. A liquid make-up system is provided which comprises a liquid reservoir connected to the inlet, a vacuum pump connected to the second outlet and air pressure equalization means for the reservoir and the inlet tubing. When the vacuum pump is activated, make-up water is drawn into the cell from the reservoir and the air pressure equalization means equalizes air pressure in the make-up system to atmospheric pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other advantages of the invention will become apparent upon reading the following detailed description and upon referring to the drawings in which:

Figure 1 is a schematic drawing of an oxygen/hydrogen generator according to the invention;

Figure 2 is a plan view of a wafer for use in the invention;

Figure 3 is a plan view of a second wafer for use in the invention;

Figure 4 is a cross-section through an electrolytic cell according to the invention;

Figure 5 is an exploded view of components of the anode arrangement for the cell of Figure 4;

Figure 6 is an assembled anode arrangement according to the invention;

Figure 7 is a perspective view of a separator disc for upper and lower parts of the cell of Figure 4;

Figure 8 is a plan view of the top of cell of Figure 4;

Figure 9 is a schematic drawing of an injection arrangement for an internal combustion engine;

Figure 10 illustrates a physical arrangement of some of the components of the generator according to the invention;

Figure 11 illustrates a housing for the front of the arrangement of Figure 10;

Figure 12 is a schematic drawing of a level sensing device for use in the invention;

Figure 13 is a nozzle for use for gas injection in the invention; and

Figure 14 is a schematic drawing of a slightly modified generator according to the invention.

While the invention will be described in conjunction with illustrated embodiments, it will be understood that it is not intended to limit the invention to such embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, similar features in the drawings have been given similar reference numerals.

The generator 10 comprises a cell 12 having a liquid inlet 14 and a gas outlet 16. Make-up liquid is provided by liquid make-up system 18.

The cell 12 comprises lower chamber 20 and upper chamber 22, separated by separator disc 24.

Lower chamber 20 includes a base disc or bottom 26.

Lower chamber 20 of electrolytic cell 12 contains anode 28. Anode 28 comprises a stack 30 of wafers 32 and 33. Wafers 32 and 33 are mounted on

connector 34 at openings 35 and are vertically spaced on the connector by conductive washers 36. Lower end 38 of connector 34 is fixed to an insulating disc 40, and is spaced by insulating discs 40 and 42 from base 26 of casing 44 of lower chamber 20. As best illustrated in Figures 4 to 6, the stack 30 may be stabilized by support rods 46 at openings 47, rods 46 fixed to insulating disc 40 and to upper plate 48. Each wafer 32 and 33 is separated from adjacent wafers along support rods 46 by conductive washers 50.

Stack 30 is divided into an upper section 52 and a lower section 54. The wafers 33 of upper section 52 include an opening 56 to accommodate level sensing device 58. Opening 56 is absent from wafers 32 of lower section 54.

Wafers 32 may comprise expanded stainless steel discs or the like, but stainless steel mesh has been found to be particularly suitable. This mesh may have the appearance of ordinary door and window screens. Typically the screens may be less than one millimetre in thickness.

Separator disc 24, as illustrated in Figure 7, includes apertures 60 and 62 to accommodate connector 34 and level sensing device 58 respectively. Connector 34 and level sensing device 58 are sealed against leakage at apertures 60 and 62.

Separator disc 24 separates casing 44 of lower chamber 20 from casing 64 of upper chamber 22 and acts as a seal between the two. Casing 44 is electrically connected to the electrolysis circuit through connector 45. The connection is to the grounding circuit of the vehicle and thus enables casing 44 to comprise the cathode.

Figure 7 also illustrates the use of filters in the separator disc 24 to prevent egress from lower chamber 20 of moisture and of electrolyte. Thus, apertures 66, 68 and 70 are provided in separator disc 24. As illustrated, the apertures contain, as filters, porous metal alloy plates. One suitable porosity range is 5 to 50 microns. A typical material is that sold by Metal Supplies Online, Inc. under the designation "Super Alloy HASTELLOY® C276 alloy".

Upper chamber 22 functions as a gas manifold and cooling chamber for gases produced in the electrolysis process.

Top 72 of upper chamber 22 contains a number of apertures. Aperture 74 provides sealing and insulating engagement for upper end 76 of connector 34.

Aperture 78 provides sealing engagement for upper end 80 of level sensing device 58.

Aperture 82 connects to gas outlet conduit 16 through gas outlet valve 84.

Aperture 86 leads to pressure regulator 88. Pressure regulator 88 is adjustable over an appropriate range of pressure, typically 10 to 225 psi. Outlet valve 84 is controlled by pressure regulator 88 through microprocessor 152. While operating pressure for the cell will vary with specific applications, a typical value for a turbo charged diesel engine would be 50 psi. This is well above normal turbo diesel operating pressures and avoids any backpressure problems due to malfunction.

Aperture 90 connects to liquid inlet conduit 14 which is described in detail later in this description.

Aperture 92 connects to vacuum pump 94, the operation of which is also described later.

Finally, aperture 96 connects to a rupture disc 98, which acts as a final safety device. Typically, the rupture disc will blow at a pressure suitably above the cell operating pressure; e.g. 70 psi, or suitably in a range of 50 to 150 psi.

The seals may be comprised of teflon throughout.

With reference to gas outlet 16, a conduit 17 leads from outlet 16 at the top 72 of cell 12 through a first run 100 to a moisture collector 102. From collector 102, a second run 104 leads to an injector 106 in an internal combustion engine fuel supply line. Moisture collector 102 is provided with an electrically operated drain valve 108 to drain collected moisture. The valve may operate on a timing sequence such that, for example, the valve would operate for a very brief period every half hour. Pressure in the line would expel collected moisture, but the timing sequence is sufficiently short as not to have any material effect on system pressure. Typical operating time may be 0.5 seconds for each ½ hour cycle.

It is of note that first run 100 of conduit 17 may run from the top of the cell 12 in a direction toward the bottom of the cell 12, with the moisture collector 102 located at the bottom of the run which may be near the bottom of generator 10. The second run 104 then leads back to an upper part of the generator 10 and hence out of the generator and toward the engine. The vertical drop over the two

runs 100 and 104 then influences moisture condensing in the runs to flow down into collector 102.

Downstream of second run 104 the conduit 17 may include an additional moisture removing filter 110. This may be a silica gel filled filter.

Conduit 17 may also include a low pressure detector 112.

Conduit 17 may enter an internal combustion engine system at a convenient point. This point of entry may be in an air inlet to the engine and may be downstream of a turbo charger. With reference to Figures 9 and 13, an injection nozzle 114 may comprise an angled fixture 115 which enters engine fuel supply line 116 at a suitable point, and barb 117 which discharges in a direction parallel to air flow through the line. The discharge point may be on the centre line of the air supply line 116.

The electrolyte may comprise a solution of potassium hydroxide (KOH) at a suitable strength. The water part of the solution will slowly be used up in the production of hydrogen and oxygen. Accordingly, it is necessary from time to time to add make-up water to the electrolyte.

Thus, Figure 1 also illustrates a liquid make-up system 18 for cell 12. This system includes a casing 120 and a base 122. Casing 120 includes a mounting 124 for a liquid supply bottle 126. Bottle 126 opens into a reservoir 128 in base 122.

Liquid inlet conduit 15 leads from reservoir 128 in base 122 to the cell inlet 14. Conduit 15 may include a heater 130. Heater 130 may include a temperature sensor 131 to detect a preset low temperature and to switch on heater 130. A typical such low temperature preset would be 4°C.

Conduit 14 may also be equipped with a solenoid valve 132 for purposes of pressure equalization in the liquid make-up system.

The reservoir 128 includes a level detector 134 and temperature sensor 136, and a resistance heater 137.

Casing 120 may include an incandescent bulb 138. The temperature sensor 136 may act at a predetermined low temperature to switch on heater 137 and/or bulb 138. A typical such low temperature preset would be 4°C.

A door 140 on casing 120 may incorporate a cutter (not shown) to pierce the bottom of bottle 126 when the door is closed on the bottle.

As well, base 122 may include a cutter (not shown) to pierce a seal on bottle 126 when the bottle is inserted into the base.

Liquid make-up system 18 includes a vacuum system 142. The vacuum system may comprise the vacuum conduit 144 leading from aperture 92 through solenoid valve 146 to vacuum pump 94. Conduit 144 may also include filter 148, which may be a silica gel filter on conduit 144.

The level sensing device 58 also comprises a part of the liquid make-up system 18.

Level sensing device 58 may comprise a capacitive float detection system in which each measuring point combines a float and a capacitive sensing system. Thus, with reference to Figure 12, the device 58 is shown schematically positioned in cell 12.

The level sensing device 58 comprises a probe 160 having four switch points 162. Each switch point includes a capacitive sensing system 164 which measures the capacitance of the solution between probe 160 and grounded wall 44 of cell 12. Each of floats 166, when in proximity to a respective capacitive system 164, turns on the respective system to recognize the presence of the float. A signal is then transmitted to the microprocessor 152. Each float is free to travel at the electrolyte surface, between positions just above and just below its respective capacitive system, and will be recognized only when at the level of the capacitive system.

In one embodiment the capacitive system includes a sensitive amplifier 168 capable of differentiating foam and liquid. Hence, a false reading would not be accepted, should a float ride up on a foam layer.

As discussed below in the description of the operation of the cell, the levels sensed preferably comprise "full" and "low" levels, bounding the normal operating range; and "high shutdown" and "low shutdown" levels, which are assumed to be triggered by a malfunction and thus comprise safety levels.

The generator 10 includes a casing 150 and may be provided with a cooling system to bring ambient air into casing 150 and expel heated air from the casing. The cooling system may comprise one or more cooling fans 149 in a housing 151.

Generator 10 includes a microprocessor 152, which is electrically connected to at least one power supply 154 and to the various described sensors

and valves to control the generator. Power supply 154 is also connected to the anode and cathode to power the cell. The power supply 154 receives power from the internal combustion engine electrical system. Power supply 154 is typically operating in the range, or adjustable over the range, of 12 volts/20 amps to 2.5 volts/120 amps.

In one embodiment the power supply operates at full power at 120 amps.

In another embodiment the power supply is controlled by microprocessor 152 to operate over the range specified above, responsive to engine load.

In operation, the cell 12 will be filled to a "full" level with a suitable electrolyte solution. On ignition of the internal combustion engine to which the generator is connected, the microprocessor 152 will activate the electrical circuitry causing current to flow through the cell and liberating hydrogen and oxygen in lower chamber 20 of cell 12.

Once the pressure in the cell reaches the operating pressure, as detected in the pressure regulating valve 88, the valve will open and permit the flow of gas to the internal combustion engine.

Operation will continue in tandem with operation of the engine, and the electrolyte level in cell 12 will slowly decrease as liquid is broken down in the electrolysis process to yield the product gas mixture. When the level sensing device 58 detects that the level of electrolyte in cell 12 has reached a "low" level, this information will be transmitted to the microprocessor 152, and the microprocessor will shut down operation of the cell and initiate the liquid make-up system 18. At all times during operation the system 18 will include bottle 126 of make-up liquid, normally distilled water.

The vacuum pump will then be switched on and solenoid valve 146 opened to reduce pressure in cell 12. Solenoid valve 147 in liquid inlet conduit 14 will then be opened to permit the flow of liquid from bottle 126 to cell 12. Once the level of electrolyte again reaches the "full" level, the vacuum pump will be shut down and solenoid valve 147 also shut down to prevent further inflow of make-up liquid. Normally, a typical vacuum pump might operate for less than 20 seconds per fill cycle. The microprocessor will then restart the generator.

Various safety factors may be built into the system, triggered by electrolyte level. Thus, a high shutdown level may be included such that the microprocessor

will shut down the generator should the level sensing device 58 detect that electrolyte has reached that level. Conversely, a low shutdown level may also be provided.

The level detector 134 in base 128 will indicate to the microprocessor and hence to the vehicle operator that the liquid level in the reservoir is low, signalling that bottle 126 must be replaced.

The described temperature sensors will work through microprocessor 152 to control the various heaters as required. This will generally only be at start-up in particular climates

CLAIMS:

1. An anode arrangement for use in a hydrolysis cell for generating hydrogen and oxygen gas, said arrangement comprising a series of non-vertically oriented perforated electrically conducting wafers, vertically spaced from each other, and a connector for connecting each said wafer of said series to an electrical circuit.

2. The arrangement of claim 1 wherein each said wafer includes multiple perforations.

3. The arrangement of claim 1 wherein each said wafer comprises a mesh.

4. The arrangement of claim 1 wherein each said wafer is a wire screen.

5. The arrangement of claim 1 wherein each said wafer is a stainless steel screen.

6. The arrangement of claim 1 wherein said wafers are substantially horizontally oriented.

7. The arrangement of claim 6 wherein said connector comprises a substantially vertically oriented electrically conducting connector rod upon which said wafers are mounted.

8. The arrangement of claim 7 wherein said wafers are separated from each other by electrically conducting washers mounted on said rod.

9. The arrangement of claim 8 further comprising at least one electrically conducting support rod spaced laterally from said connecting rod and on which said wafers are supported, spaced from each other by electrically conducting washers.

10. The arrangement of claim 9 further including non-conducting upper and lower caps in which upper and lower ends of each said at least one support rod are fixed.

11. The arrangement of claim 10 wherein a lower end of said connecting rod is fixed in said lower cap.

12. An anode arrangement for use in a hydrolysis cell for generating hydrogen and oxygen gas, said arrangement comprising a series of perforated electrically conducting wafers, said wafers vertically spaced from each other, and said wafers comprising a congruent vertical stack, and a connector for connecting each said wafer to an electrical circuit.

13. An anode arrangement for use in a hydrolysis cell for generating hydrogen and oxygen gas, said arrangement comprising a vertical stack of perforated electrically conducting wafers, said wafers vertically spaced and arranged congruently such that produced gas moves upwardly in said cell through said stack.

14. An electrode arrangement for a hydrogen/oxygen electrolysis cell, said arrangement comprising:

an anode comprising a series of substantially horizontally oriented perforated wafers vertically spaced from each other;

a connector assembly for connecting each said wafer of said series to an electrical circuit; and

a cathode spaced from said anode.

15. A hydrolysis cell for generating hydrogen and oxygen, said cell comprising:

a casing, said casing being at least in part electrically conducting and constituting a cathode;

an anode according to claim 6 within said casing and electrically insulated therefrom;

means for introducing make-up liquid into said cell; and

means for removing produced gas from said cell.

16. The cell of claim 15 wherein said casing comprises upper and lower parts, and wherein said lower part comprises said cathode.

17. The cell of claim 16 wherein said upper and lower parts of said casing are sealed together.

18. The cell of claim 16 wherein said upper and lower parts of said casing are separated by a sealing plate, said plate having at least one area therein permitting passage of gas from said lower to said upper parts.

19. The cell of claim 18 wherein each said at least one area comprises a porous plate.

20. The cell of claim 19 wherein said porous plate is a metallic alloy.

21. The cell of claim 15 wherein said means for removing produced gas comprises an outlet opening in a top of said cell.

22. The cell of claim 21 wherein said outlet opening is connected to a pressure control valve which will allow gas to exit said cell when a preset operating gas pressure in said cell has been reached.

23. The cell of claim 22 wherein said preset operating pressure is in the range of 35 to 50 psi.

24. The cell of claim 22 wherein said preset operating gas pressure is 50 psi.

25. The cell of claim 22 wherein said pressure control valve is adjustable over a range of operating pressures.

26. The cell of claim 13 further comprising liquid level sensing means for sensing the level of electrolyte in said cell.

27. The cell of claim 26 wherein said level sensing means comprises a capacitive system for sensing electrolyte level in said cell.

28. The cell of claim 27 wherein said level sensing means comprises a probe, at least one capacitance measuring component for measuring the capacitance between said component and a wall of said cell, a float associated with said probe, and means for transmitting a signal representative of said capacitance to a central processor, and wherein the positioning of said float in proximity to said component activates said component to measure said capacitance.

29. The cell of claim 28 comprising at least two said components respectively representative of a full and a low level of said electrolyte.

30. The cell of claim 29 comprising an additional two said components representative of upper and lower unsafe levels of said electrolyte.

31. A hydrogen and oxygen generator comprising:

an electrolytic cell comprising a casing, an anode, a cathode, an inlet and first and second outlet; and

a liquid make-up system for said cell comprising a liquid reservoir connected to said inlet, a vacuum pump connected to said second outlet, and air pressure equalization means located between said reservoir and said inlet and responsive to activation of said vacuum pump;

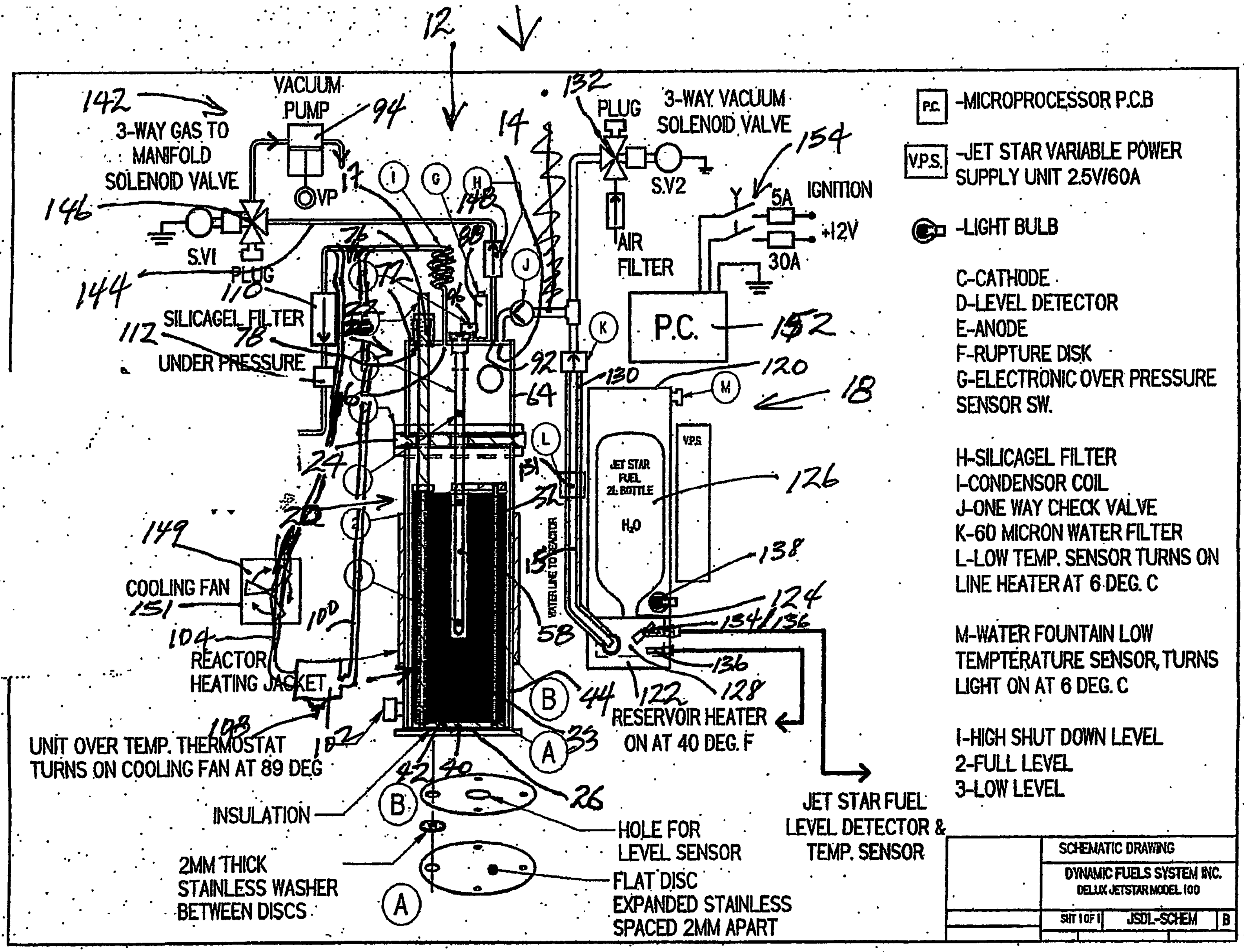
whereby, when said vacuum pump is activated, make-up water is drawn into said cell from said reservoir and said air pressure equalization means equalizes air pressure in said make-up system to atmospheric pressure.

32. The generator of claim 31, including a microprocessor controller for receiving condition signals from said generator and outputting control signals to said generator.

33. The generator of claim 32, wherein said generator includes:

a level sensor for sensing liquid level in said cell and for transmitting said liquid level to said controller;

means in said controller for analyzing said signal and outputting a signal to activate said liquid make-up system or to shut down said generator.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14
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MANIFOLD
SOLENOID VALVE
VACUUM
PUMP
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VP
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PLUG
144
110
SILICAGEL FILTER
112
78
UNDER PRESSURE
76
72
96
98
148
132
PLUG
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SOLENOID VALVE
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AIR
FILTER
154
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30A
P.C.
152
92
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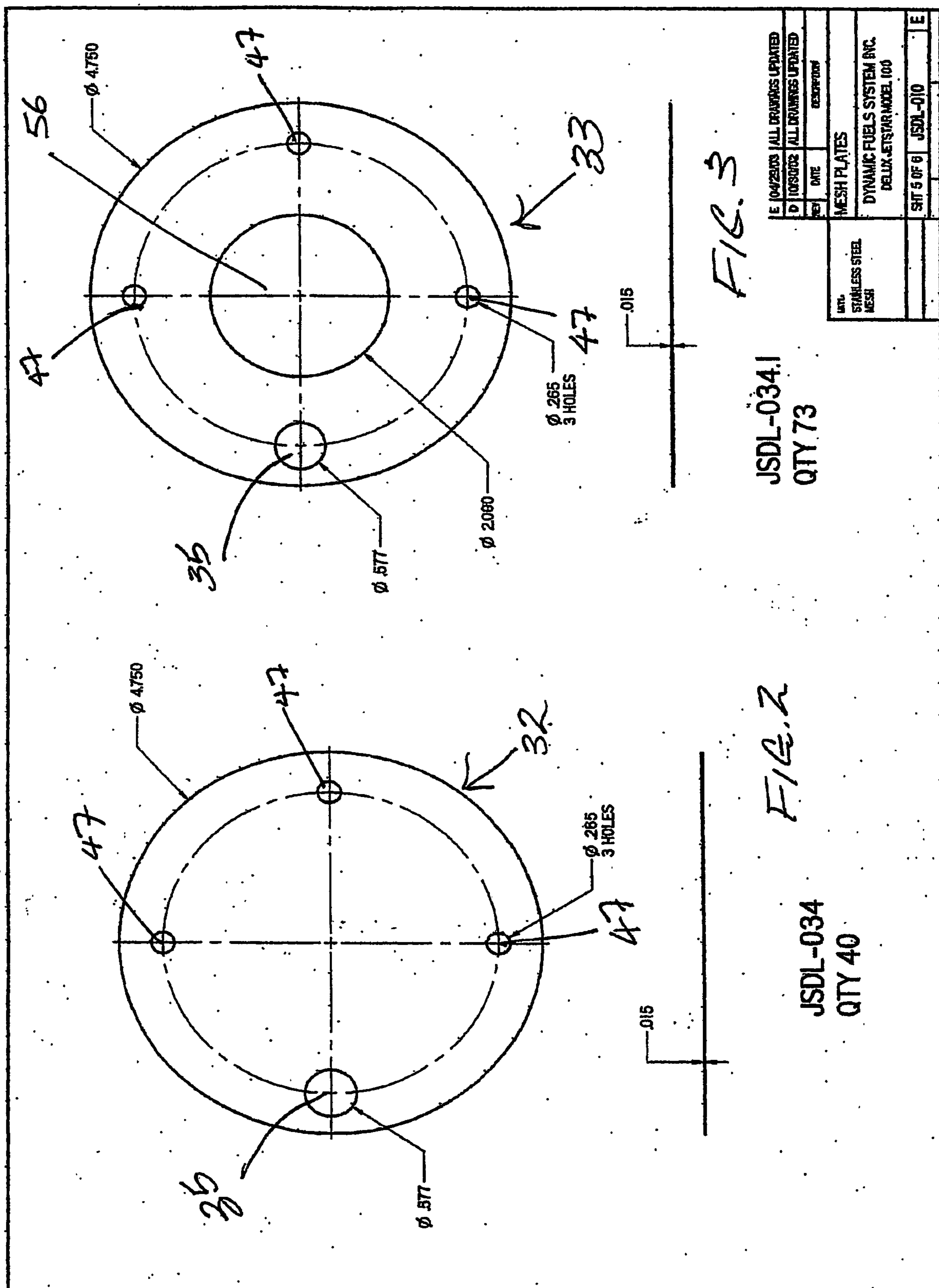
130
120
18
24
22
149
COOLING FAN
151
100
104
REACTOR
HEATING JACKET
108
102
UNIT OVER TEMP. THERMOSTAT
TURNS ON COOLING FAN AT 89 DEG
42
40
26
INSULATION
2MM THICK
STAINLESS WASHER
BETWEEN DISCS
HOLE FOR
LEVEL SENSOR
FLAT DISC
EXPANDED STAINLESS
SPACED 2MM APART
131
32
15
WATER LINE TO REACTOR
58
44
33
JET STAR FUEL 2L BOTTLE
H2O
V.P.S.
126
138
124
134
136
128
122
RESERVOIR HEATER
ON AT 40 DEG. F
JET STAR FUEL
LEVEL DETECTOR &
TEMP. SENSOR
P.C. -MICROPROCESSOR P.C.B
V.P.S. -JET STAR VARIABLE POWER
SUPPLY UNIT 2.5V/60A
-LIGHT BULB
C-CATHODE
D-LEVEL DETECTOR
E-ANODE
F-RUPTURE DISK
G-ELECTRONIC OVER PRESSURE
SENSOR SW.
H-SILICAGEL FILTER
I-CONDENSOR COIL
J-ONE WAY CHECK VALVE
K-60 MICRON WATER FILTER
L-LOW TEMP. SENSOR TURNS ON
LINE HEATER AT 6 DEG. C
M-WATER FOUNTAIN LOW
TEMPTERATURE SENSOR, TURNS
LIGHT ON AT 6 DEG. C
1-HIGH SHUT DOWN LEVEL
2-FULL LEVEL
3-LOW LEVEL
SCHEMATIC DRAWING
DYNAMIC FUELS SYSTEM INC.
DELUX JETSTAR MODEL 100
SHT 1 OF 1
JSDL-SCHEM
B

FIG. 1.



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DELUX JETSTAR MODEL 100
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FIG. 3

FIG. 2

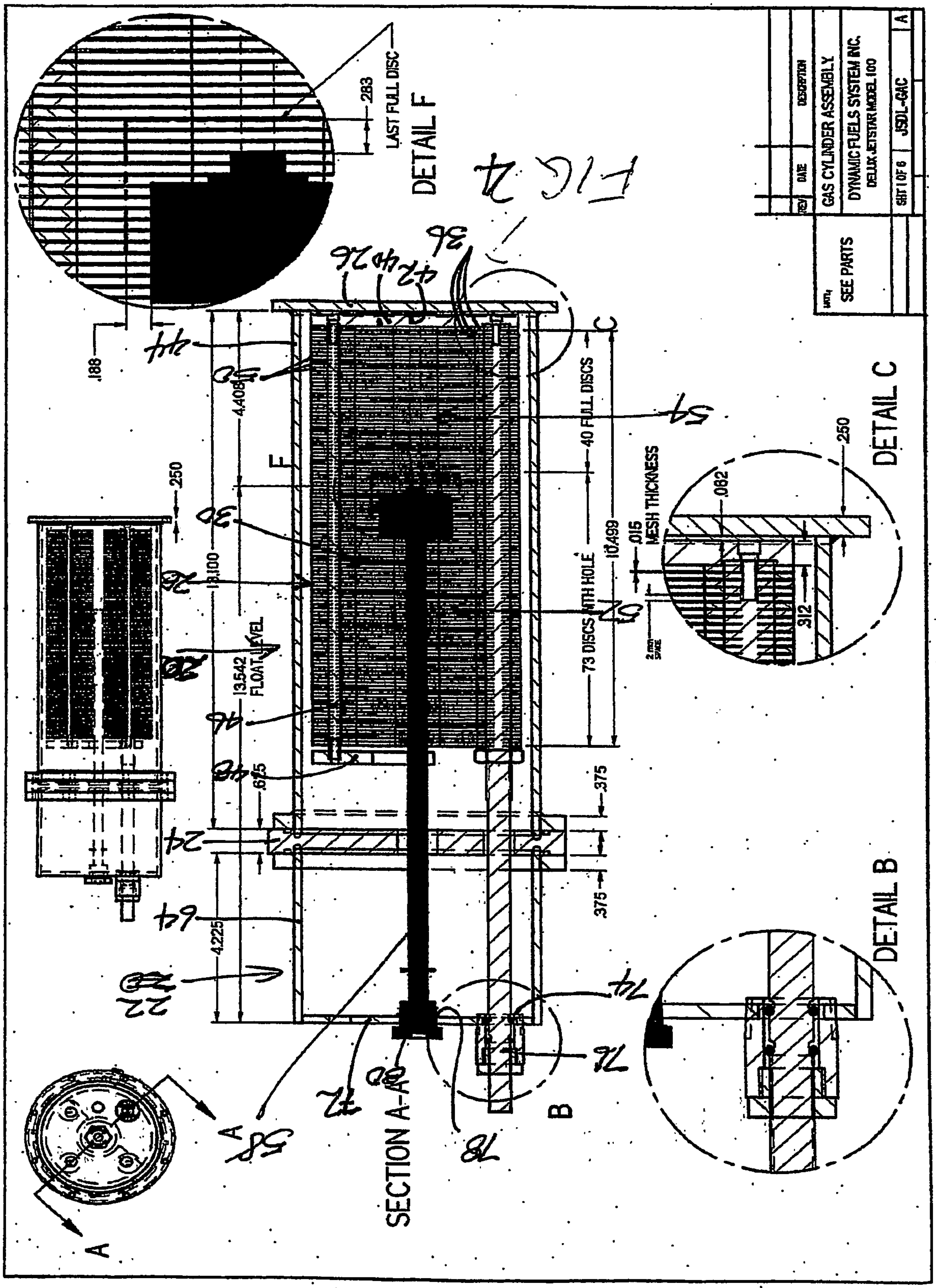
FIG 2
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DATE
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LAST FULL DISC
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DETAIL C
.250
.062
.015
MESH THICKNESS
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13.100
13.542
FLOAT LEVEL
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4.225
.250
B
C
F
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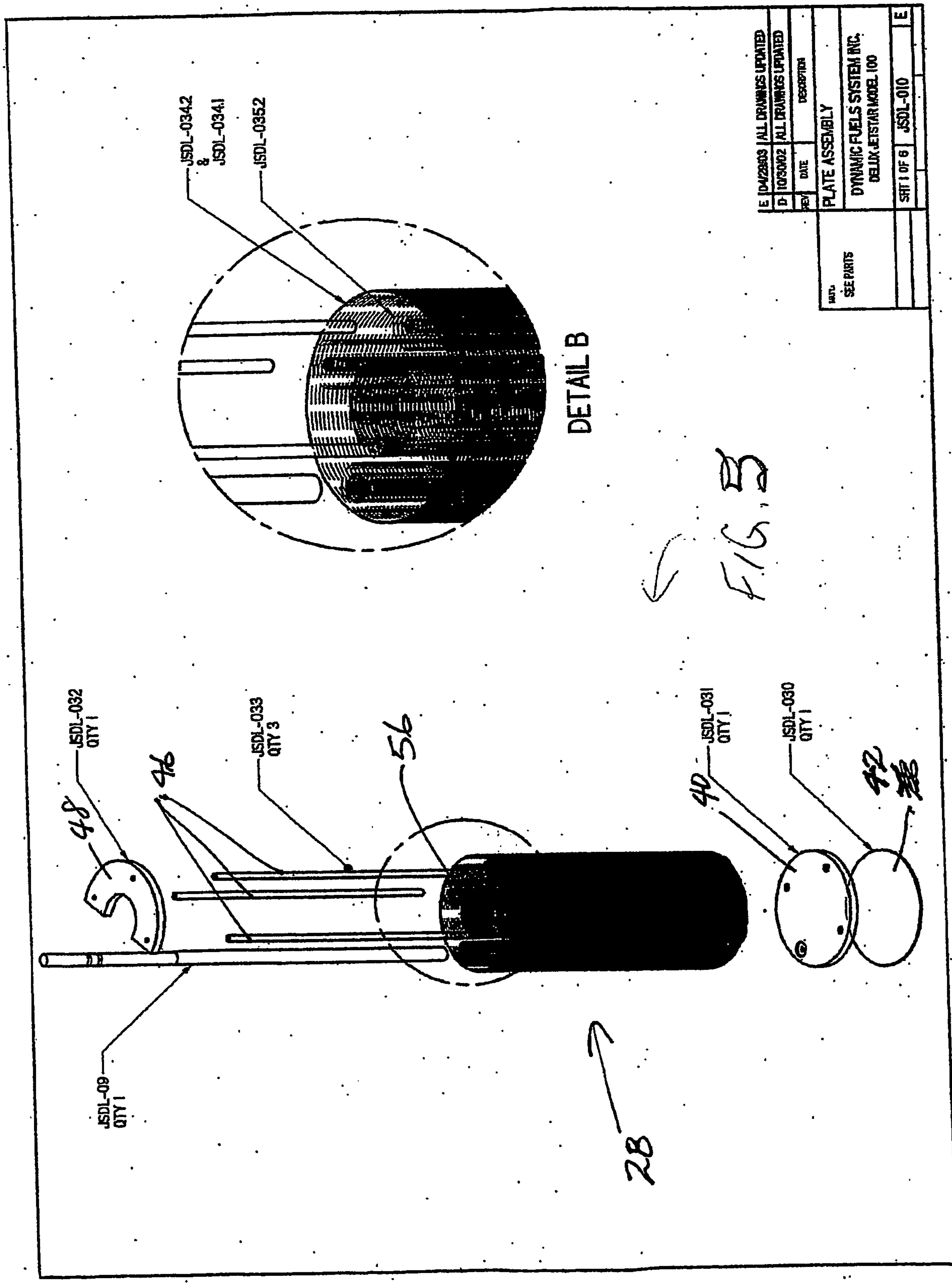
78
80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JSDL-09
QTY 1
28
E | 04/28/03 | ALL DRAWINGS UPDATED
D | 10/30/02 | ALL DRAWINGS UPDATED
REV | DATE | DESCRIPTION
PLATE ASSEMBLY
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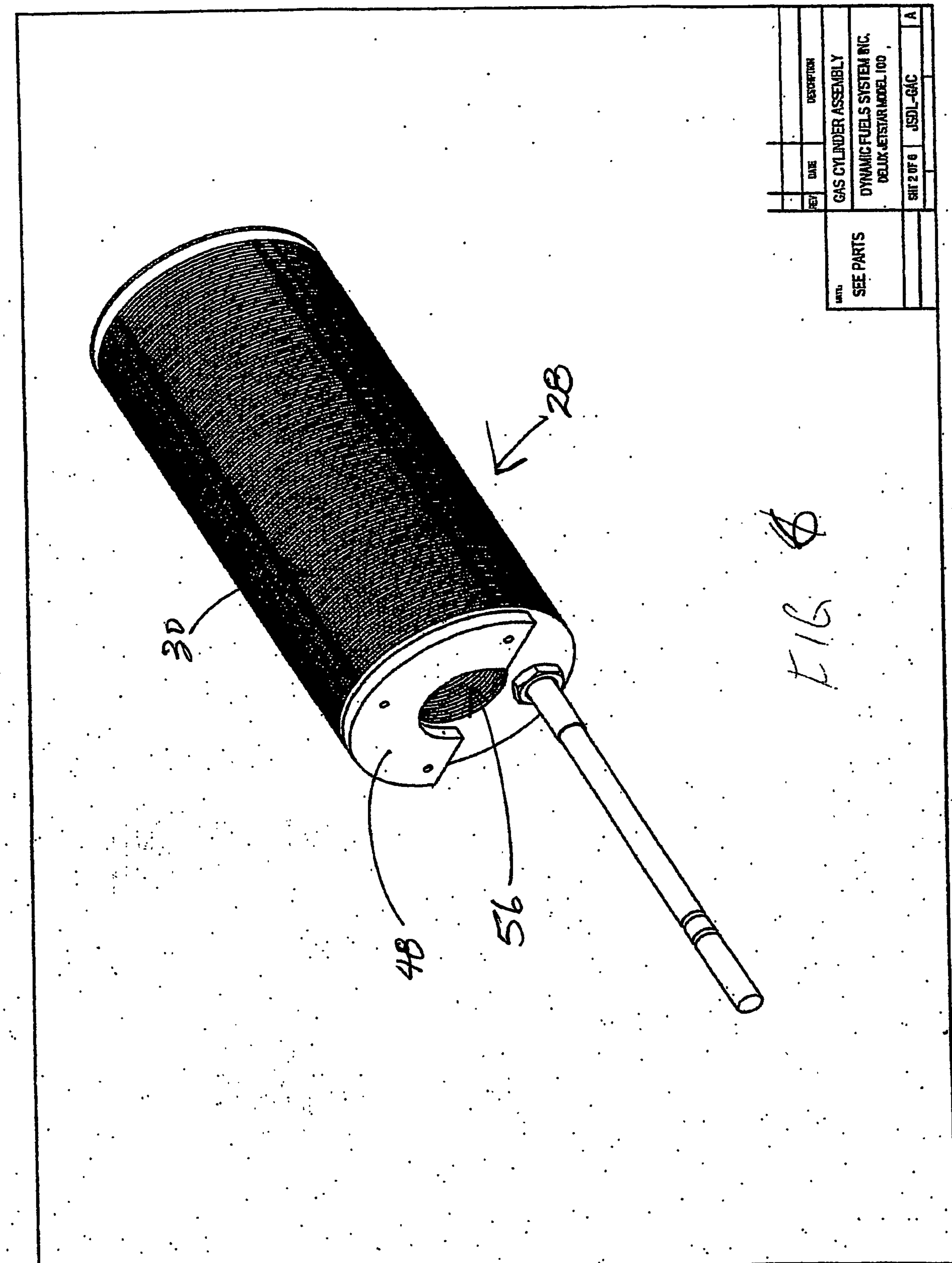
DELUX JETSTAR MODEL 100
SHT 1 OF 6
JSDL-010
E
MAT'L
SEE PARTS

FIG. 5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DATE
DESCRIPTION
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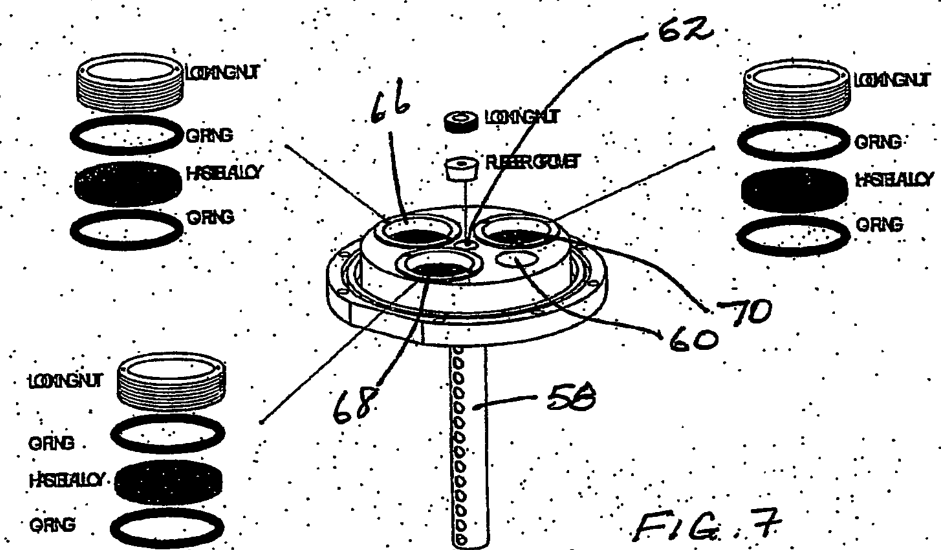
DYNAMIC FUELS SYSTEM INC.
DELUX JETSTAR MODEL 100
MAT'L
SEE PARTS
SHT 2 OF 6
JSDL_GAC
A
28
30
48
56

FIG 6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HASTELLALOY
ORING
66
LOCKINGNUT
RUBBER GROMMET
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HASTELLALOY
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70
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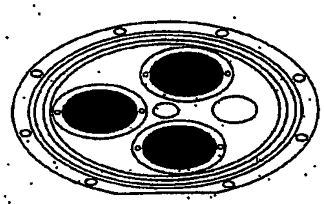
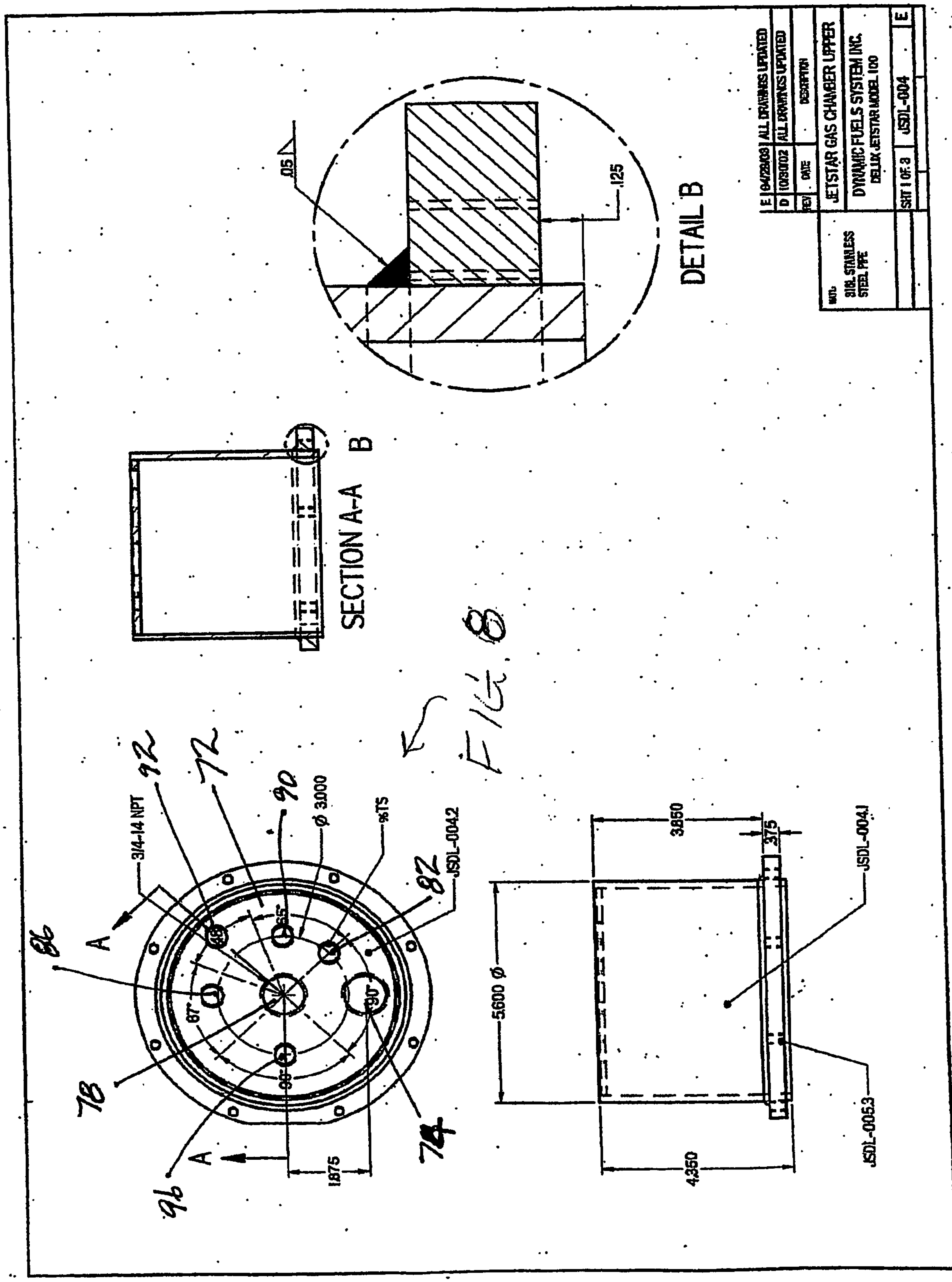
ORING
HASTELLALOY
ORING
68
58

FIG. 7




DETAIL B
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JSDL-004.1
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JETSTAR GAS CHAMBER UPPER
DYNAMIC FUELS SYSTEM INC.
DELUX JETSTAR MODEL 100
SHT 1 OF 3
JSDL-004
E
316L STAINLESS STEEL PIPE

FIG. 8

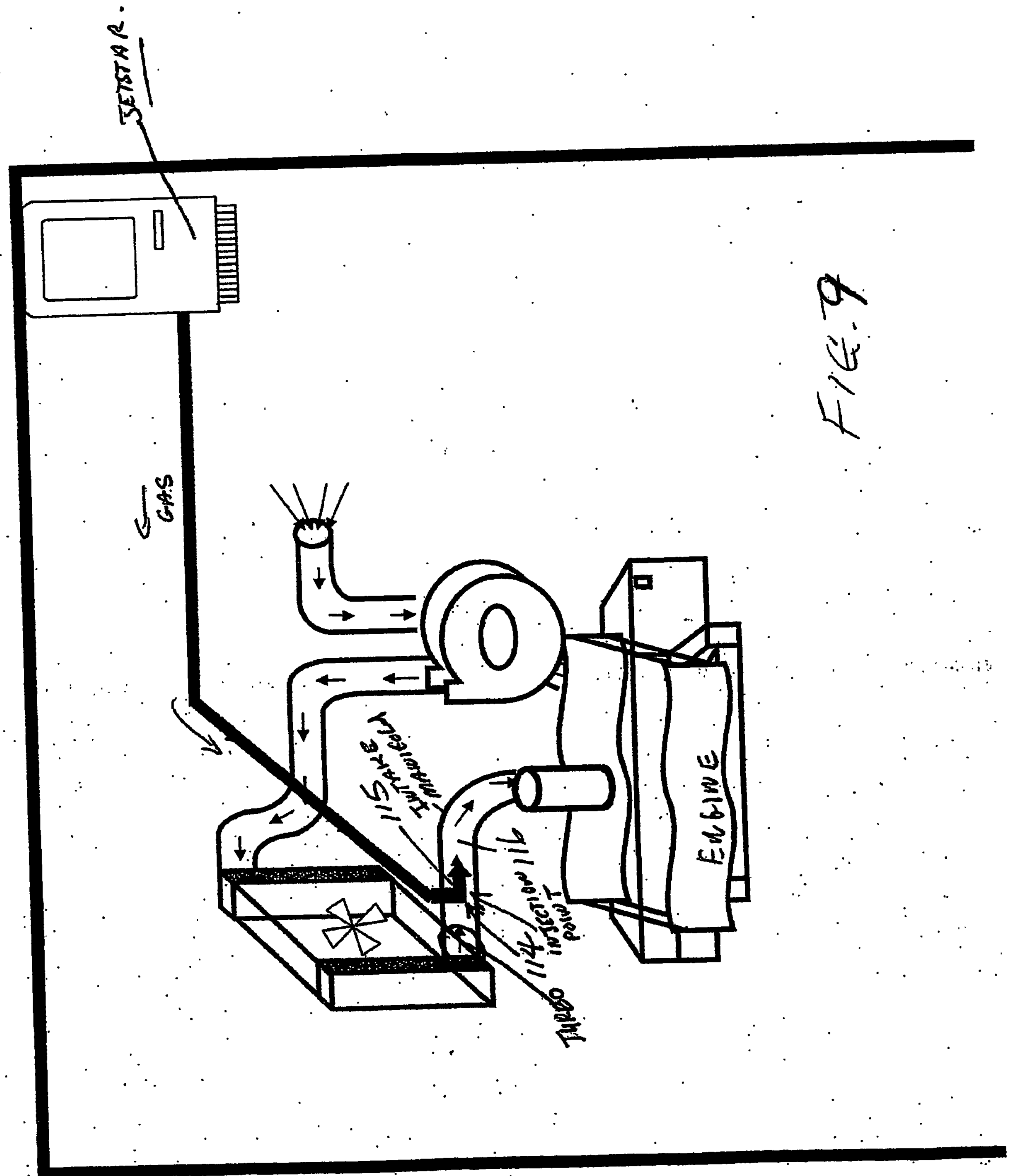
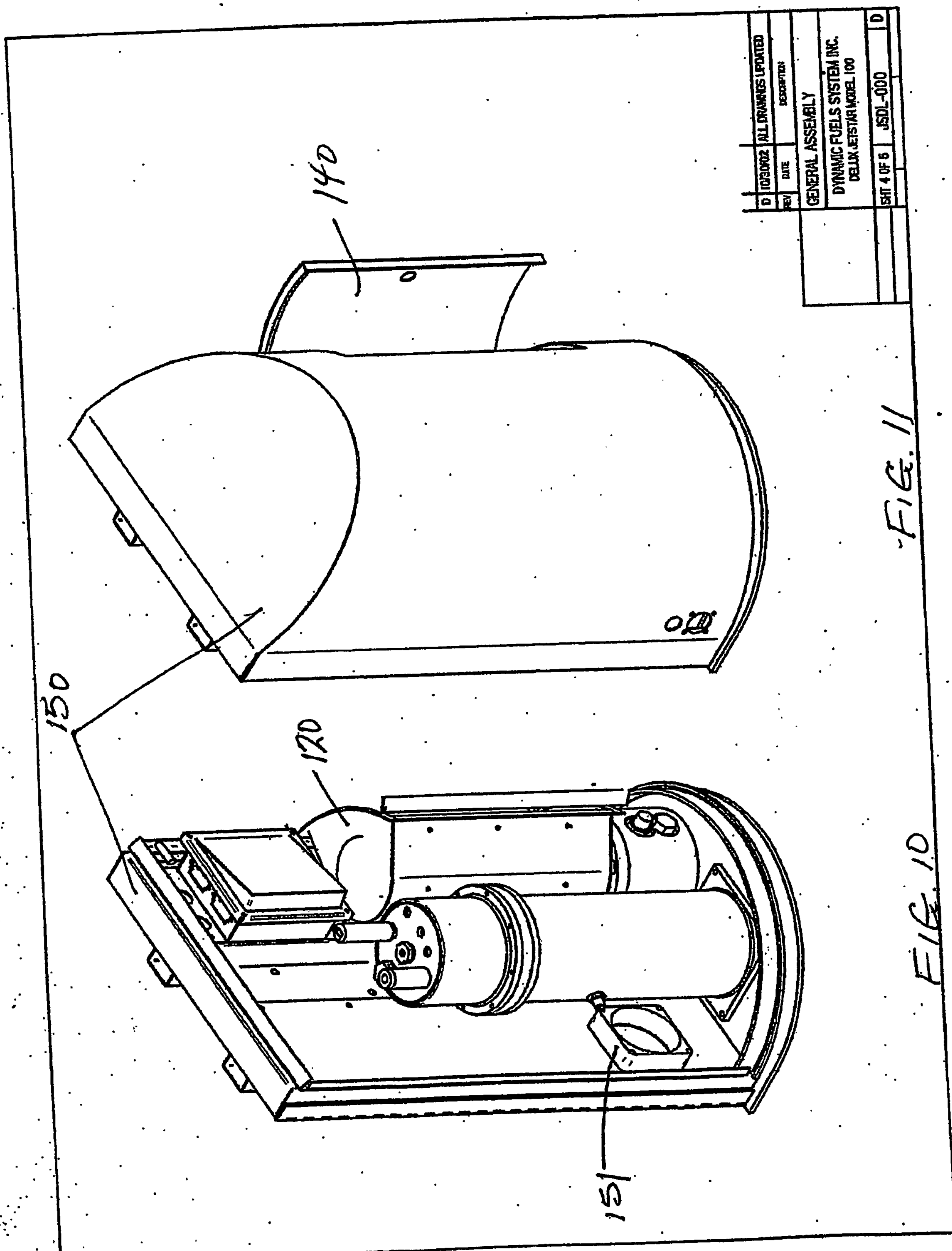

JETSTAR.
GAS
115 INTAKE MANIFOLD
116
114 INJECTION POINT
TURBO
ENGINE

FIG. 9



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SHT 4 OF 5 JSDL-000 D
140
150
120
151

FIG. 10

FIG. 11

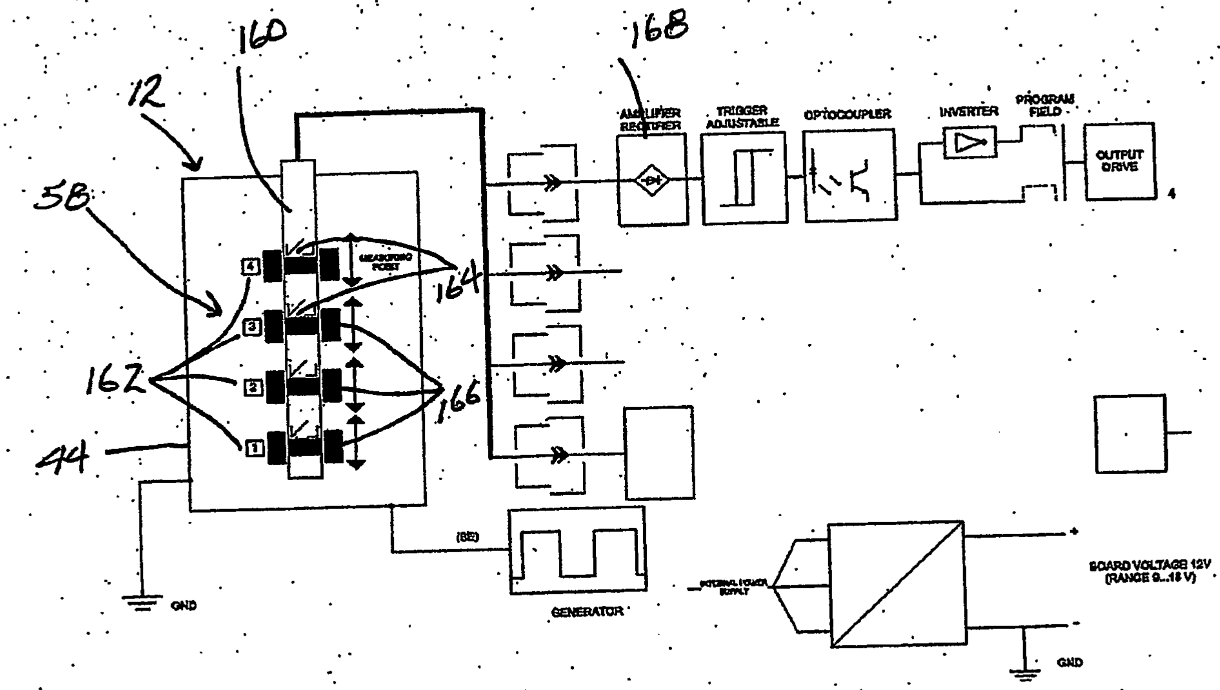
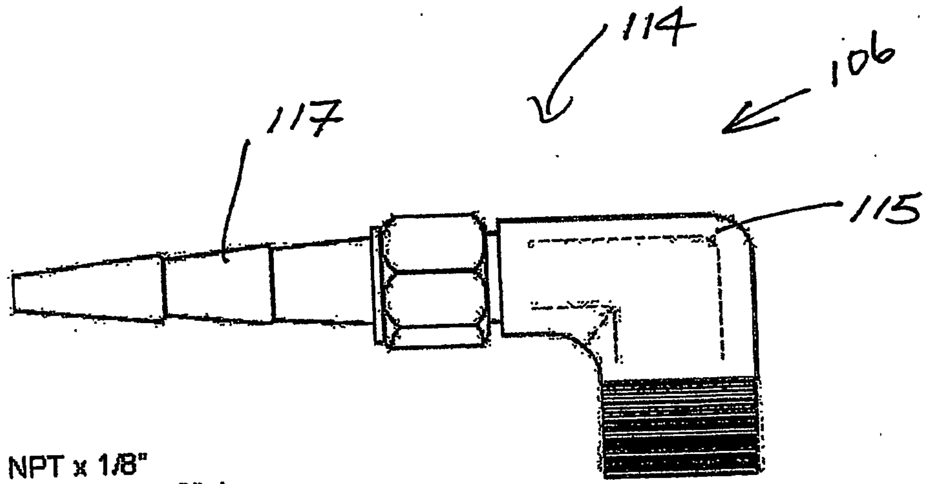

160
168
12
58
AMPLIFIER RECTIFIER
TRIGGER ADJUSTABLE
OPTOCOUPLER
INVERTER
PROGRAM FIELD
OUTPUT DRIVE
4
MEASURING POINT
164
4
3
2
1
162
166
44
GND
(SE)
GENERATOR
BOARD VOLTAGE 12V
(RANGE 9...18 V)
GND

FIG. 12



1/4" NPT x 1/8"
Length of Barb is 2" Approx.
Threaded into the air intake pipe
of the engine.

FIG. 13

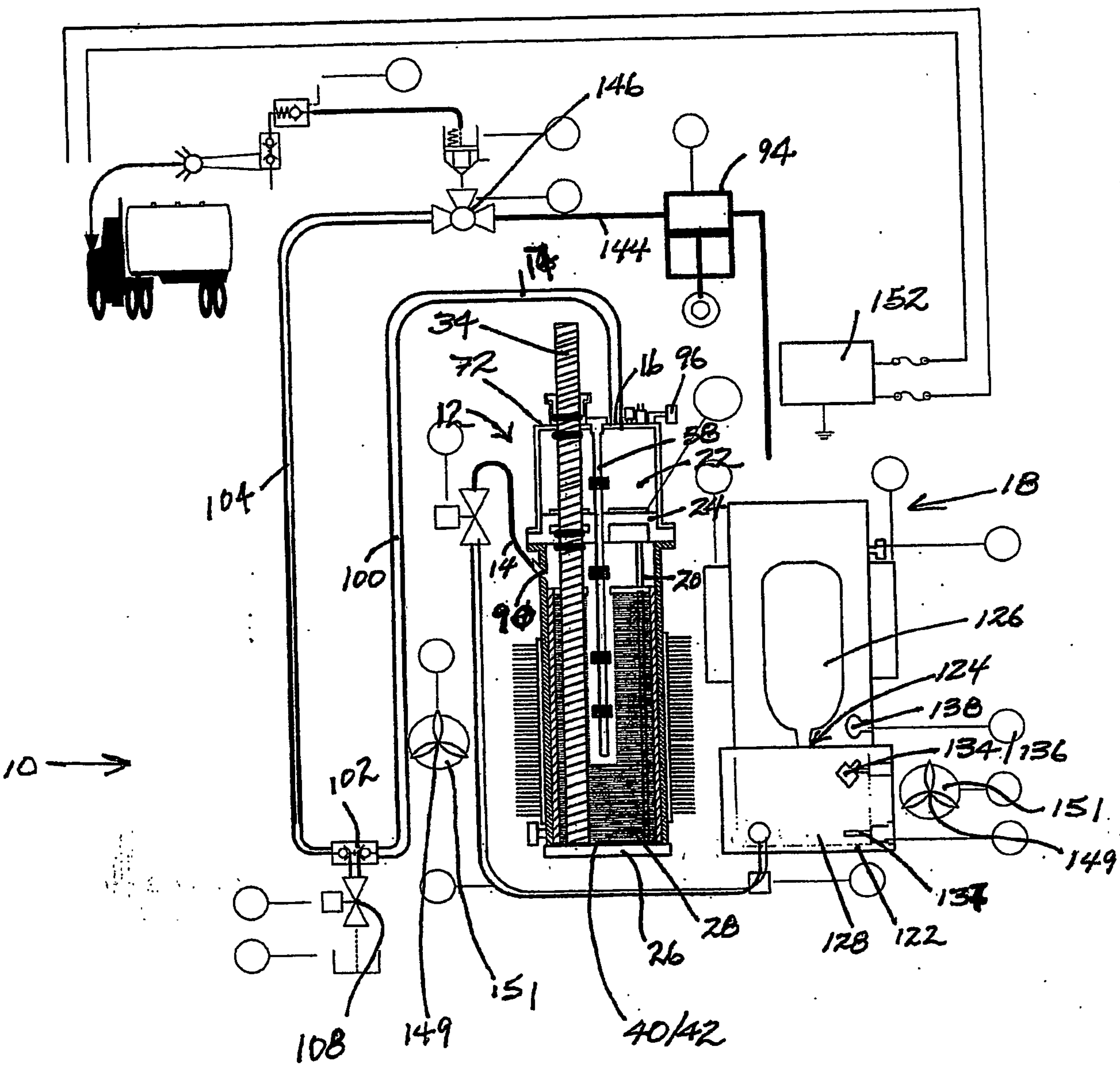

146
94
144
14
152
34
72
16
96
12
38
22
18
104
24
14
100
98
20
126
124
138
134
136
10
102
151
149
137
128
122
28
26
108
149
151
40/42

FIG. 14